JOHN INNES INSTITUTE

FIFTY-SECOND ANNUAL REPORT

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Genetics	Mrs G. E. Anderson, College of Technology, Liverpool.
Cell Biology	Dr H. W. Fisher, University of Colorado, U.S.A.

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JOHN INNES INSTITUTE

Report for the Year 1961

1. DIRECTOR'S REPORT

Very satisfactory progress has been made during the year in four departments but the programme of work in the Department of Applied Genetics has suffered a setback owing to loss of staff: three of its members resigned in the course of the year.

Most of our developments have been in the Department of Cell Biology which is well on the way to becoming a completely functional unit. Several new posts have been filled and a good deal of internal construction and reconstruction has been done in the new building. A fair number of internal fittings are still needed but by next year the whole laboratory should have been adapted to the needs of its occupants. Several major items of physical equipment, including an analytical ultracentrifuge, have now been installed and are in use.

Staff

Dr Watkin Williams left in August to return to the University from which he joined us seven years ago, having accepted the appointment of Professor of Agriculture (Crop Production) at King's College in the University of Durham. He goes with our regrets and good wishes.

Mr N. E. G. Gilbert relinquished his post in order to take a course on biophysics in the University of Edinburgh. Dr R. M. Whittle and Mr G. D. Rowley have both moved to teaching posts; the former as Lecturer in Physics at the Regent Street Polytechnic and the latter as Lecturer in Horticultural Botany at the University of Reading. Dr K. K. Pandey left for New Zealand at the end of the year where he will join the Crop Research Division of the Department of Scientific and Industrial Research.

Two biochemists and a physical chemist were appointed during the year. Mr W. T. Riley was trained in the Department of Biochemistry at the University of Oxford and Dr T. Spencer in the Department of Physical Chemistry; they will both work in the Department of Cell Biology. Dr A. Coddington, graduated in Chemistry at Imperial College, University of London, and joins the Department of Genetics.

Changes in Trustees and Council

Professor T. Wallace, F.R.S., a member of Council for several years, has accepted an invitation to become a Trustee to fill the vacancy caused by the death of Hon. Sir David Bowes-Lyon, K.C.V.O.

Sir Frederick Stern has relinquished the Chairmanship of Council which he held for thirteen years and Lieut.-Colonel James Innes was elected to succeed him. Professor R. D. Preston, F.R.S. is the new representative nominated by the Minister for Science and the Minister of Agriculture, Fisheries and Food.

Conferences and Visits

Dr H. Harris gave an invited paper on 'Nuclear Ribonucleic Acid' to the Vth International Congress on Biochemistry held in Moscow from 10 to 16 August. Dr J. R. S. Fincham also attended.

Mr N. W. Simmonds visited Jamaica in February as a member of the Advisory Committee on Banana Breeding Research.

Miss M. Jahnz was away during the first two months of the year to learn about the culture of *Acetabularia* in Professor J. Hämmerling's Department at the Max-Planck Institut für Meeresbiologie, Wilhelmshaven, Germany.

In April Dr J. R. O. Dawson attended a short course on Cellular Biology and Basic Virology at the University of Glasgow.

Several members of staff attended and contributed papers to scientific meetings in the United Kingdom.

Visits

As usual many visitors came to the Institute, including parties of students from the Universities of Cambridge, Dublin, London (Royal Holloway College), Nottingham and Swansea.

In November Dr H. W. Howard gave a talk to the Seminar Club on 'Eelworm versus Potatoes' and in December Dr P. W. Brian, F.R.S. spoke about 'Gibberellins'.

New Fruit Selections

The descriptions of an apple seedling and three new cherry seedlings which have been named and formally released by Council are given at the end of this *Report*. They are all seedlings selected from crosses made many years ago. The strawberry Merton Princess is also described. It is becoming quite popular with growers in the Wisbech area.

2. DEPARTMENT OF APPLIED GENETICS: DR DODDS'S REPORT

Breeding New Varieties

Apples. Mr Brown continues to make progress in the long task of selecting improved varieties of top-fruits. To economize in the use of land, as much selection as possible is being done while seedlings are still close-planted in nursery rows. Of 3800 apple seedlings from crosses between parents with some resistance to mildew, planted in 1959, and still in the nursery, more than 40 % have so far proved susceptible to this fungus and have been discarded.

The programme of breeding for resistance to Scab (*Venturia inaequalis*) is well advanced thanks to the recurrent help that is obtained from Professor J. R. Shay of Purdue University, U.S.A. We have been receiving pollen each year from one or two of his most advanced selections from backcrosses between cultivars and resistant *Malus* species and the pollen is used by Mr Brown at Bayfordbury for further backcrosses. Our least advanced progenies represent three generations of backcrossing and our most advanced represent five. This season, 1550 seedlings were tested with an inoculum consisting of a mixture of races of the fungus and about 750 were scored as resistant. They were planted with those already in the field and we now have a total of 4500 seedlings for general selection. It has become evident since the inception of this programme that these backcross progenies vary a great deal in their reactions to mildew. Scores of the intensity of infection have been kept during the past three years and now only seedlings which showed little infection are being used for further crosses. We hope eventually to select seedlings with resistance to both scab and mildew.

Five apple seedlings will be submitted shortly to the National Fruit Trials at Brogdale.

Cherries. Mr Matthews has examined the reactions to the bacterial canker organism (*Pseudomonas mors-prunorum*) of about a hundred varieties of sweet cherries (including the most important cultivars and twenty-five Merton selections), eight Duke cherries, three sour cherries and forty-eight species of *Prunus*.

The tests on sweet cherry varieties were made by making ten separate inoculations into two-year-old wood in December and scoring responses in the following April. The results agreed very closely with the susceptibility scores given by N. H. Grubb from field observations (*Cherries*, London, 1949).

Mr Matthews has also studied the influence of the age of wood on the response of a variety to bacterial canker by serial inoculation along branches from current year's growth to wood estimated to be nine years old. Four varieties were used: three responded by forming the largest cankers on two-year-old wood (Merton Bigarreau, Merton Bounty and F 12/1); but in the fourth, Merton Heart, the older the wood, the larger were the cankers.

Although several commercially important varieties are highly resistant to bacterial canker, e.g. Cleveland Bigarreau, Frogmore Early, Guigne de Winkler (Belle Agathe), Turkish Black, Merton Glory, and Merton Heart, there is not a sufficient number of them to meet the needs of growers in terms of season, quality and high yield of fruit. It is felt that a breeding programme to fill this gap is well worthwhile. The work is badly handicapped by two factors. First, 'stones' of all the early and early mid-season varieties are almost always inviable and so only later varieties than these can be used as female parents. Secondly, cherries are self-sterile and to undertake hand pollinations on a large scale calls for more labour than we can spare. This problem will be solved by using stones from open pollinated flowers. They are being collected from orchards where the stones have most probably been set by pollination between resistant varieties selected by Mr Matthews as potentially valuable parents; for example, one orchard contained the two varieties Turkey Heart and Noir de Guben and in this instance, the pollinator was probably Early Rivers. About 20,000 stones have been collected in this way for use next season.

A prerequisite for efficient breeding against bacterial canker is a means of testing the reaction of young plants. Mr Matthews has made good progress towards the development of a reliable test of resistance in first-year seedlings. Five leaves are detached from a seedling five to six months' old and a drop of inoculum is placed on each freshly exposed scar. Reaction is assessed by the behaviour of the bud above the inoculated leaf scar: in resistant seedlings, the growth of the bud is slow; in susceptibles it is suppressed. There is a time-of-year effect, however, such that inoculations made in August are much more likely to succeed than inoculations made in September or October; and this must be taken into account in planning the tests. To check the method, this type of test was made with grafts of one-year-old scions on young stocks of F 12/1 using twenty-five grafts of each of five varieties. In every instance, the scion variety reacted according to the level of resistance that it was known to have as a mature tree.

Strawberries. In the general programme of breeding, which is being carried out by Mr Williams and Mr Smith, many of the progenies that are now being raised are from repetitions on a large scale of crosses that gave high proportions of good seedlings when tried on a small scale. As a result, the number of seedlings that are being selected for further examination is on the increase. For the time being it is proposed to meet this situation not by reducing the size of progenies but by applying more rigorous standards of selection than in the past. About 8 % (357 out of 4705) of the seedlings from crosses made in 1958 have been selected this year, after fruiting twice, for further trials as clones of six plants.

Studying crosses between advanced selections Mr Williams and Mr Smith have found some that give progeny that are resistant to mildew and bear uniformly heavy yields of large fruits. It may be possible with this material to stabilize these characters in the population at high mean values and so give more attention to other attributes such as fruit quality and resistance to other diseases.

Mr Williams is carrying out a programme of moderate inbreeding (by sib-mating) to increase the amount of homozygosity for desirable characters. It has become evident that, although some of the inbred progeny show loss of vigour, the loss is not sufficiently great seriously to hinder progress in selection. The aim is to breed parents which will have high combining ability and will give a consistently high proportion of valuable offspring.

Seedling J.I. 663 (*J.I. Report*, 1958) has done extremely well each year in the yield trial which has just been discontinued after running for two years. This season it outyielded Red Gauntlet by 23 % and Talisman by 32 %. None of the other selections in the trial equalled these two standard varieties in total yield but one or two gave better early crops.

Tomatoes. Dr Dawson is exploring the possibility of breeding tomatoes resistant to tobacco mosaic virus by using Line Z316 (*J.I. Report*, 1959). So far, four backcrosses have been made, two each to Ailsa Craig and Potentate as recurrent parents; but it is too soon yet to be able to tell whether a satisfactory level of resistance can be maintained by selection. One disconcerting feature of the crosses is that a number of symptomless carriers occur. A commercial variety with complete tolerance of the virus is not desirable since it could serve as a reservoir of infection. This is the reason why we have decided to stop work on Lines Z545 and Z546 in the breeding programme. They are difficult to infect but the virus usually does get into the plants after inoculation and they become symptomless carriers. It is felt that this type of resistance would not be economically satisfactory.

The interaction of host and virus. As a first step in a study of the interaction between host and virus, Dr Dawson is examining the differences between susceptible and 'resistant' tomato plants in the distribution of tobacco mosaic virus. The 'resistant' seedlings are derived from Lines Z316, Z545 and Z546 and they only become infected when a high titre of virus is used in the inoculum. The seedlings do not show symptoms of infection and the amount of virus in them remains low. Dr Dawson is trying to find the conditions that will consistently lead to a spread of virus in seedlings with resistance to infection, as compared with the sporadic spread that takes place under ordinary conditions. Several methods are being used: for example, the use of more than one leaf for inoculation, repetitive inoculations and the use of carborundum with the inoculum.

The migration and multiplication of virus in the susceptible variety Ailsa Craig has been examined during a period of fourteen days, after inoculating the cotyledons and the first true leaf of each of a number of plants four weeks old. Daily samples of sap were taken from terminal leaflets and the virus in each sample was assayed by using *Nicotiana glutinosa* and by direct counting of virus particles under the electron microscope. This was done with the spray droplet technique (H. L. Nixon and H. L. Fisher, *Brit. J. appl. Phys.* **9**, 68, 1958) with the help of Mr Crawley. The two methods gave a similar picture of the distribution of virus. Traces of virus were detected in the inoculated leaf about six days after inoculation and in the next two leaves higher up the stem on about the seventh day. The concentration of virus in these three leaves remained extremely low thereafter. Traces of virus were

detected in the fourth and younger leaves on the sixth day and the concentration in them had increased by the eighth day. It stayed at a high level in these younger leaves for the remainder of the experiment.

Tomato chromosomes. The twelve pairs of tomato chromosomes are individually distinguishable at pachytene and Mr Snoad is trying to relate their cytological maps with the genetical ones. At the outset he is paying particular attention to chromosome 2 which bears the nucleolar organizer and has several other clear morphological features. Seven plants heterozygous for X-ray induced interchanges involving this chromosome have been isolated and cytological examination shows that the seven breaks are all in the long length of heterochromatin in which the centromere lies. If, as there is reason to believe, chiasmata are not formed in the heterochromatin of tomato chromosomes, linkage between any one gene and these seven points of interchange should be constant, since the linkage value measures the distance between the locus and the near-end of the heterochromatin. This is being checked by using genes *d*, *p*, *o* and *s* of chromosome 2. The value of linkage between *s* and *T*, the point of interchange, has indeed been found to be about the same, thirty-eight cross-over units, in all seven interchange heterozygotes. The linkage values between *d*, *p*, *o* and *s* agree quite closely with published results in all the test crosses and so it may be assumed that pairing in the region of these genes is not affected by interchange. As would be expected, the distance between a gene and a point of interchange in the heterochromatin measured in cross-over units has no direct relationship to the physical distance. By contrast, interchanges in the euchromatin should show correlation between linkage values and physical distance.

Antibiotic-like Substances produced by Species of Pseudomonas

Mr Matthews has continued to study the inhibitory reactions that occur when some isolates of *Pseudomonas* are grown together. He has been able to select colonies of an isolate of *Ps. mors-prunorum* that are resistant to the antibiotic-like substances produced by one of his isolates of *Ps. syringae*, by plating the two species together. But the resistant colonies were found to have retained their sensitivity to the antibiotic-like substances produced by some isolates of *Ps. phaseolicola* and *Ps. aptata.*

Twenty-one isolates of *Ps. mors-prunorum* that could not be distinguished morphologically were kindly supplied by Dr J. E. Crosse of East Malling Research Station; eleven of them were found to be 'producers' of antibiotic-like substances and ten were 'non-producers'. The growth of nine of these non-producers was inhibited by any of the eleven producers but the tenth was not affected. Although all the producers inhibited the growth of the same non-producers, there were obvious differences between the producers as shown by the shape, size and intensity of the zone of inhibition which each gave with a particular non-producer. This suggests that there were corresponding differences in the amounts of antibiotic-like substances liberated by the producers. The growth of all the twenty-one isolates was inhibited by a strain of *Ps. syringae.*

Rose Rootstocks and Sucker Production

An important criterion in attempting to assess the value of different rose rootstocks is the extent to which they throw suckers either from underground stem buds or adventitiously from the root. Factors influencing sucker production have been studied by Mr Rowley from 1958 onwards, using the twelve stocks in the existing three rootstocks trials.

Suckering has been found to depend first on the stock variety, whether grown as a seedling or as a cutting, and the extent to which a cutting was disbudded before planting. On the basis of total sucker output over three seasons' growth, four categories can be recognized:

1. Very low suckering—less than one sucker per ten plants			
multiflora	0·03	*coriifolia* Laxa	0·09
2. Low—up to one sucker per plant			
canina Heinsohn's Record	0·17	Pollmeriana	0·28
3. Moderate—one to two suckers per plant			
Spek's Rugosa	1·05	*canina* Brog's	1·6
canina Pfander's	1·1	*multiflora* Superba	1·6
canina wild	1·5	*canina* Schmidt's Ideal	1·8
4. High—over two suckers per plant			
canina Senff	2·2	Manetti	5·2

Of the above rootstocks, *multiflora*, *multiflora* Superba, Spek's Rugosa and Manetti were raised from cuttings; the remainder from seed.

A second factor influencing suckering is the size and vigour of the whole plant. A large bush throws more suckers from the roots than a dwarf. Thus, in the first stock trial Peace, an outsize shrub, induced formation of almost as many suckers as all seven other smaller Hybrid Tea scions put together (taking the results for eight rootstocks collectively). At the other extreme, a dying scion may become surrounded with suckers so the generalization for plant size holds good only when the combined plant is fully compatible and healthy.

Finally, soil conditions have a pronounced effect on the root system and its tendency to throw up shoots, as the following Table will show.

TABLE 1. *Rose suckering and soil type*

Year	Total rootstock suckers for all stocks and scions combined: Light soil	Heavy soil	Ratio
1958	14	89	1:6·4
1959	9	115	1:12·8
1960	20	116	1:5·8

Clearly, in selecting new stocks for lowness of suckering, comparisons are valid only if all are budded from the same scion (which should be vigorous) and grown on similar, preferably rich, soil.

Species Collection

The identities of the following were verified by Mr Rowley during 1961:

Prunus avium L., *avium* L. *actiana* (L.) Schneid., *avium* L. *plena* (West.) Schneid., *cerasus* L. *marasca* (Reich.) Schneid., *emarginata* (Hook.) Walp., *maackii* Rupr., *mahaleb* L. *pendula* Dipp., *mochidzukiana* Nakai, *nipponica* Mats., *nipponica* Mats. *kurilensis* (Miy.) Wils., *pilosiuscula* (Schneid.) Koehne, *spinosa* L. *plena* Schneid., *spinosa* L. *purpurea* (André) Schneid., *triloba* Lindl. *triloba*, *virginiana* L.

Malus coronaria (L.) Mill.

Pyrus pyrifolia (Burm.) Nakai.

3. DEPARTMENT OF GENETICS: DR FINCHAM'S REPORT

Genetic Control of an Enzyme in Neurospora crassa

Dr Fincham returned in June after spending ten months in the Department of Biology, Massachusetts Institute of Technology. While there, he developed a procedure for obtaining the triphosphopyridine nucleotide-linked glutamic dehydrogenase of *N. crassa* in nearly pure form. Ultracentrifugal analysis indicates that the enzyme is a large molecule, with a molecular weight of the order of 200,000. On the other hand, digestion of the protein with trypsin, followed by two-dimensional separation of the resulting peptides by electrophoresis and chromatography ('fingerprinting'), gives a relatively simple pattern consisting of only about 30–35 peptide spots, suggesting a very much lower molecular weight. It thus seems likely that the enzyme as isolated is an aggregate of identical sub-units. It is hoped that definitive information on these points will soon be available. Dr Coddington, who joined the Department in December, is attempting to improve the purification procedure so as to make it more suitable for the preparation of the relatively large amounts of reasonably homogenous enzyme which will be necessary for any more detailed analysis of the structure of the protein.

The enzyme isolation procedure has been applied to a number of strains carrying various mutant alleles of the *am* series. Particular attention has been given to mutants showing mutual complementation. Among the primary series of mutants, am^1 was already known to be complementary to am^2 and to am^3. A third mutant complementary to am^1 has recently been isolated and designated am^{12}. Each of these mutants produces a protein which resembles the wild-type enzyme in its fractionation characteristics and electrophoretic mobility at pH 8·4 in starch gel. The am^1 protein has not been shown to possess any enzyme activity, but the am^2, am^3 and am^{12} proteins are all able to catalyse the oxidation of glutamate in a system containing TPN and a high concentration of glutamate at a relatively high pH value. These enzyme varieties seem, in fact, to be activated by glutamate, and are virtually inactive in glutamate synthesis (the presumed physiological function of the normal enzyme) unless glutamate at high concentrations is already present. The am^2 and am^3 enzymes are readily distinguishable by their kinetic properties, but the am^3 and am^{12} varieties are very similar or identical. This finding is in good agreement with genetic data communicated by Dr J. A. Pateman of the Department of Genetics, Cambridge University; am^3 and am^{12} show no recombination and may well be mutant at the same site within the gene, while am^2 and am^3 are mutant at different sites. It is interesting, and probably significant, that in each of the three pairs of primary *am* mutants which show complementation, one partner is am^1, while

the other is a mutant capable of producing a potentially active variety of the enzyme. It is tempting to suppose that the am^1 enzyme sub-unit is able to 'hybridize' with a sub-unit produced by am^2 or am^3 in such a way that the latter is stabilized in its active form. The possibility that the wild-type enzyme is an aggregate of identical sub-units is of great interest in this connexion.

Glutamic dehydrogenase has been purified from the secondary mutants (isolated as incomplete revertants) am^{2l}, am^{3a} and am^{3b}. The purified enzymes retain the distinguishing properties previously observed in experiments with cruder preparations. All appear to resemble the wild-type enzyme in electrophoretic mobility at pH 8·4. So far no way is known of separating any of the various mutant enzymes from each other or from the wild-type enzyme. Such methods will have to be developed before the situation in complementing heterocaryons can be satisfactorily analysed.

Preliminary fingerprints of the am^2 and am^3 proteins have shown no convincing differences between these mutant varieties and the wild-type. However, the possibilities of this experimental technique have by no means been exhausted.

Expression of a Gene of Defined Biochemical Function in Different Genetic Backgrounds

By hybridization and backcrossing, Mr Harrison has transferred am^{2l}, which in *N. crassa* controls the formation of a characteristically abnormal glutamic dehydrogenase variety, to *N. sitophila*. Backcrossing has proceeded to the point where strains carrying am^{2l} are fully fertile with *N. sitophila*. Preliminary tests have shown no effect of the altered genetic background on the nature of the enzyme formed. *N. crassa* stocks of very diverse geographical origins are at present being used as sources of genetic variation in a search for modifiers of the action of various *am* alleles.

Control of Mating Type in Coprinus lagopus

The analysis of mating type factors in *Coprinus* has been continued by Dr Day. As has been previously reported (*J.I. Report*, 1959) the *A* 'locus' of this fungus is composed of at least two sub-units called α and β.

The sub-unit constitutions of seven different *A* factors of local origin and two from material collected in Poland by Dr K. M. Swiezynski, Institute of Genetics, Skierniewice, have now been determined, and are shown below:

A_5	1957	$\alpha_5\beta_5$
A_6		$\alpha_6\beta_6$
A_7	1961	$\alpha_5\beta_7$
A_9		$\alpha_9\beta_9$?
A_{14}		$\alpha_{14}\beta$?
A_{16}		$\alpha_9\beta_{16}$
A_{34} Poland		$\alpha_5\beta_{34}$
A_{13}		$\alpha_5\beta_{13}$
A_{13} Poland		$\alpha_5\beta_{13}$

One of the Polish *A* factors was incompatible with a local *A* factor, and it is of interest to note that the two factors are identically constituted. Among the eight different *A* factors four α and at least five β specificities were found. Because of the low frequency of recombination between α and β (0·07 %) the tests for factor constitution were made by crossing an *ad*-8 recombinant of the unknown *A* factor with *paba*-1 A_5 and *paba*-1 A_6. The markers *ad*-8 and *paba*-1 are on either side of the *A* locus. The prototrophs from each cross were selected and screened for non-parental *A* factors, and these were tested against each other. Crosses homozygous for α give no recombinants; the identity of α_5 in the several strains containing it was confirmed by the recovery of $\alpha_5\beta_6$ recombinants from crosses with A_6. The similar analysis of ten other *A* factors was blocked by the failure to obtain *ad*-8 recombinants in progenies of 200–300 adenine requirers in each example.

The total sample of wild *A* and *B* factors now examined in *Coprinus lagopus*, from twenty-eight monocaryons of local origin and six of Polish origin, includes thirty-two different *A* factors and twenty-nine different *B* factors. Two *A* factors were each recovered twice; three *B* factors were recovered twice and one three times.

It was reported last year (*J.I. Report*, 1960) that the fruiting of common *A* heterocaryons was due to mutation *either* at or close to the *A* locus (two examples) *or* at an unlinked 'suppressor' locus (one example). A further ten mutants of the former type have now been obtained. An extensive analysis of crosses of all these with wild *A* factors has failed to show any recombination generating the original *A* factor. Evidently each of these mutations is within, or very close to, either the α or the β sub-unit. An analysis of the sub-unit constitutions of the mutant *A* factors was undertaken by the selective technique outlined above. Four of the mutants were found still to carry the original α sub-unit, and at least two of these had apparently lost the original β sub-unit. Three other mutants yielded neither the original α nor the original β sub-unit, and are presumably either mutant in both sub-units or altered in such a way as to prevent or restrict crossing-over in the *A* region. A small deletion or inversion could have this effect.

Further investigation of the recessive suppressor mutant gene mentioned above, has shown that it will interfere with the expression of six different *A* factors indiscriminately. Monocaryons carrying the suppressor bear false clamp connexions and form fruit bodies when inoculated to dung. The fruit bodies have high proportions of one, two and three spored basidia in addition to the normal four spored ones.

The Genetics of Ustilago maydis

Dr Holliday's work on *Ustilago maydis* continues to be mainly concerned with mechanisms of recombination and mutation.

Somatic recombination. In order to make a comparison between the effect of ultra-violet light on intragenic recombination with that on intergenic recombination, several diploids have been synthesized from inositol-dependent haploids each carrying one of the two mutant alleles *inos*-2 and *inos*-3. Since

these two mutants are non-complementing, the diploids have a requirement for inositol. They would be expected to revert to inositol independence following intragenic somatic recombination, as occurs in similar heteroallelic diploids in yeast (H. Roman, *Cold Spr. Harb. Symp. quant. Biol.* **21**, 175, 1956). The rate of spontaneous reversion was found to be low (*c.* 2×10^{-8}), but this could be increased over 100-fold after treatment with ultra-violet light. As was expected, the rates of reversion in homoallelic diploids (homozygous for *inos*-2 or *inos*-3), were significantly lower. Preliminary data indicate that the quantitative relationship between the ultra-violet dose and the rise in intragenic recombination is similar to that in diploids in which somatic recombination between widely spaced markers is examined. This provides evidence for the basic similarity of the recombinational event in the two systems. On the other hand, if normal recombination between *inos*-2 and *inos*-3 is occurring, then it should be possible to demonstrate strong correlation of the reversional event with the segregation of a marker, *nic*-3, which is linked to the inositol locus and distal to it. Such a correlation was not observed, whether *inos*-2 or *inos*-3 was in coupling with the *nic*-3 locus. The interpretation of the results is partly obscured by the fact that, since the reversion rates with this pair of alleles are so low, a proportion of the reversions are due to mutations rather than intragenic recombination.

Mutation and replication. Reversion from auxotrophy to prototrophy in micro-organisms is a very convenient system for studying the mechanisms of induced mutation. As a result of numerous investigations with haploid bacteria or fungi there has been considerable discussion as to whether the mutational event affects the parental gene *in situ*, or whether, as a result of an error in replication, only a daughter gene becomes mutant. With appropriate diploid strains of *Ustilago*, it is possible to devise a simple test which should distinguish between these two possibilities. Amongst prototrophic reversions induced by ultra-violet light in strains homozygous for a biochemical marker, a small proportion would be expected as a result of mitotic crossing-over to have become homozygous for other loci which were originally heterozygous. If revertant colonies are found which consist of the reciprocal products of mitotic crossing-over, this demonstrates that the mutation of the biochemical marker to wild type must be present in both daughter cells of the first division after irradiation; or, in other words, that the mutation was due to a chromosomal change which was transmitted not to just one, but to both chromatids. Using this system two mutations have so far been studied: reversion to inositol independence in a diploid homozygous for *inos*-3, and reversion to adenine independence in a diploid homozygous for *ad*-1. Both diploids were heterozygous for various other biochemical markers. In each case, by using the appropriate medium for selecting induced reversions, mutant colonies were detected which consisted of reciprocal products of mitotic crossing-over between the centromere and one of the markers which was originally heterozygous. The evidence indicates that a fairly high proportion of mutations induced by ultra-violet light are due to permanent changes in the pre-existing gene. From these results it also follows that ultra-violet irradiation of a cell in which the chromosomes

are not yet divided can stimulate subsequent mitotic crossing-over between chromatids. This indicates that the experiment designed to distinguish between copy-choice and breakage-reunion models of crossing-over that was outlined in last year's *Report* would not give a meaningful result; and suggests that one of the assumptions on which the latter experiment was based, namely that ultra-violet light killing is due in large measure to the induction of recessive lethal mutations, was not valid.

Selection of auxotrophs by means of inositol starvation. During experiments with inositol-requiring strains, it was noticed that cells deprived of inositol died very quickly; whereas cells with an additional biochemical requirement did not do so. This made it possible to devise a very simple technique for selecting new biochemical mutants similar to that used in *Neurospora* (H. E. Lester and S. R. Gross, *Science*, **129**, 572, 1959). If large populations of cells of a haploid inositol-requiring strain are starved of inositol for three or four days, about one per million survives, and up to one-third of these are spontaneous biochemical mutations with a requirement additional to that of inositol. Most of these requirements are for amino acids, purines or pyrimidines. Using the same technique it is possible to select spontaneous segregants from diploids which are homozygous for inositol requirement, whilst being heterozygous for other biochemical markers. After inositol starvation, up to 90 % of the survivors are segregants. All these appear to be diploids homozygous for particular markers. These experiments demonstrate that haploidization is not a regular occurrence during the spontaneous somatic segregation of heterozygous diploids of *Ustilago*.

Genetic control of nitrate reductase. In detailed studies of intragenic recombination it is desirable to work with a locus which controls a known enzyme, since this may make it possible to distinguish between true recombination and gene conversion. Using the inositol starvation technique, a search has been carried out for mutants similar to the *am* series in *Neurospora*, and also for those unable to use nitrate as sole source of nitrogen. Some of these would be expected to lack the enzyme nitrate reductase, which is responsible for the conversion of nitrate to nitrite, and which has been detected in a number of organisms including fungi. Although it has been shown that glutamic dehydrogenase is present in *Ustilago*, no *am* mutants have so far been obtained. A mutant has been isolated, however, which is capable of using nitrite as sole source of nitrogen, but is unable to grow on nitrate. When this mutant and the wild-type were grown on a medium containing ammonium and nitrate ions, nitrate reductase was detected in crude extracts from the wild-type cells, whereas there was no activity in the extract from the mutant. In a mixture of the two extracts there was no inhibition of the wild-type activity. It has been shown that very low concentrations of sodium azide in the medium prevents the wild-type from utilizing nitrate, and in fact converts the wild-type into a phenocopy of the mutant. It is uncertain whether the azide represses the synthesis of the enzyme or is inhibiting its action.

The nitrate mutant shows normal single gene meiotic segregation, and it is loosely linked to the *b* mating type locus. Crosses in which both parents carry the mutant are fully fertile, so this locus should be very suitable for

examining intragenic recombination. So far attempts to isolate further mutants allelic to the first have not been successful; but by means of reconstruction experiments, using mixtures of mutant and wild-type cells, it should be possible to refine the selection procedures and find the correct conditions for isolating new mutants.

Mutability in Antirrhinum majus

Reference was made in the last *Annual Report* to the very marked effect of temperature on the frequency of spots and flakes of anthocyanin containing cells in the otherwise acyanic flowers of two apparently mutable lines of *Antirrhinum majus*. Mr Harrison showed that in both the 'high' and the 'low' lines the frequency of spots was very much less at 25° than at 15° C.; indeed the 'low' line gave no spots at all at the higher temperature. Seed formed by selfing of plants grown at the different temperatures was grown to determine whether the temperature difference had affected the rate of mutation among the germ cells. The experiment was inconclusive inasmuch as no seedlings with self-coloured flowers were obtained from the seed of either line grown at either temperature. It was clear that mutation in the germ cells, and in the tissues giving rise to them, must, at least in the 'high' line grown at 15° C., be very much less frequent than the change to pigment production in the cells of the petals. A total of 758 germinated seeds from the 'high' line at the lower temperature included no mutants in spite of the fact that the flowers from which they came had petals in which pigmented sectors and spots almost predominated over acyanic tissue. This observation raises again the question of whether the initiation of pigment production in the petal spots is of the nature of a mutation in the usual sense. Nevertheless, seedlings with self-coloured flowers have often been observed in the 'high' line grown under field and ordinary glasshouse conditions. The conditions favouring the appearance of these whole plant mutants have yet to be defined.

Reciprocal grafts have been made between plants of the 'high' and 'low' lines. There was no apparent effect of the stock on the flaking frequency in the flowers of the scion in either graft. Young buds of the 'low' line were treated with X-rays at intervals during their development, the total dose being 5000 r. No increase in the frequency of pigmented spots was evident.

A number of crosses have been made to check the belief that the spotting patterns are due to alleles at the *pallida* locus. So far it has been established that the genes responsible are not allelic either to *incana* (for which most ivory and yellow varieties are homozygous) or to the totally albino mutant *nivea*. A number of authentic alleles of the *pallida* series have been assembled from various sources, and the relationship of our stocks to these should become clear during the coming season.

Seed Storage

Mr Harrison has stored tomato seed of the variety Ailsa Craig at 27° C. for fourteen years. Scoring for rogues in plants grown from the stored seed has

been practised since the seed was seven years old until the present time. During this seven-year period fresh seed has been saved each year from plants grown from old seed. The data as a whole show a much higher incidence of rogues among plants grown from old seed (229 out of 2374, or 9·65 %) than among those raised from one-year-old seed (6 out of 1557, or 0·38 %).

It was reported last year that plants grown from thirteen-year-old seed showed a significant decrease in yield as compared with those from fresh seed. This year a field trial was conducted to check this result, and also to see whether the deterioration in yield could be transmitted to a further generation. The trial consisted of six replicated blocks each containing plants grown from the fourteen-year-old seed, from one-year-old seed harvested from the previous year's plants grown from thirteen-year-old seed, and from one-year-old seed harvested from plants also grown from one-year-old seed. These three types of seed may be called 'old', 'fresh' and 'double-fresh', respectively. An analysis of variance on the complete harvest showed that the difference between plants raised from old seed and from fresh seed was hardly significant ($P > 0{\cdot}05$), but when the comparison was made half way through the harvest period (first picking 23 August 1961, final picking 6 September 1961) the yield from the fresh seed was very significantly greater ($P < 0{\cdot}001$). Thus the prolonged storage of the seed affected the earliness of fruit development, but the plants' potential yield is not greatly affected and can be realized provided the season allows an extended period of cropping. There was no significant difference in yield between plants grown from fresh and from double-fresh seed.

4. DEPARTMENT OF POTATO GENETICS: MR SIMMONDS'S REPORT

The Commonwealth Potato Collection

The bulk of the new accessions from the South American expedition have now either been assimilated to the Collection or destroyed. The programme of replacing tuber stocks by seed lines has also been continued during the season and the Collection is now constituted as follows:

Material	Stocks	Numbers	Remarks
Wild species	Tuber	300	70 virused stocks discarded
	Seed	530	Replacing discarded tuber stocks
Cultivated 2*x*	Tuber	280	200 additions from expedition
	Seed	220	From older tuber stocks
Cultivated 3*x*	Tuber	55	35 additions from expedition
Cultivated 4*x*	Tuber	465	340 additions from expedition
	Seed	1200	Replacing discarded tuber stocks
Domestic 4*x*	Tuber	120	
Experimental	Tuber	50	Miscellaneous clones for experimental use

We received fifty-five stocks during the year and sent out forty.

The Classification of the Cultivated Potatoes

The taxonomists who have treated the cultivated potatoes have recognized, on occasion, up to a score of 'species'. Accumulated cytogenetical investigations now show that many of these are 'bad' in the sense of being based on unreal or minor variants and that some, indeed, are merely distinctive clones; further, it is now clear that all the cultivated potatoes, however diverse morphologically, share a common origin and a common genetic system. All justification for the recognition of 'species' therefore disappears and we need to replace the formal Latin nomenclature by one which reflects the cytogenetic and agronomic facts.

Dr Dodds has now made an important contribution to the solution of this problem by providing a new system of classification based on the *Code of Nomenclature for Cultivated Plants*. It will appear in Dr D. S. Correll's forthcoming monograph of the tuberous Solanums. In essence, Dr Dodds proposed the retention of *Solanum tuberosum* L. as the prior collective name for the whole assemblage, subdividing it on the basis of ploidy, a suitable group name and, where necessary or possible, a clone name. On this basis, the merits of using well established and well understood names such as *tuberosum*, *andigena* and *stenotomum* can be admitted without the necessity of strict observance of the formal rules of typification and priority—which lead to endless confusion. Thus, we refer unambiguously to the Groups Tuberosum,

Andigena and Stenotomum but not to the supposed species which originally bore the names. This is why names previously italicized and spelled with lower case initials will, in this and subsequent *Reports*, appear in roman with initial capitals.

The Pigments of Wild Diploids

One of the most conspicuous features of the cultivated diploids is the great array of colours and colour patterns that they present in comparison with the related wild diploids. At least six loci (*P*, *R*, *Ac* and the linked complex *B*, *I*, *F*) are concerned in the system which must have evolved *pari passu* with other 'cultivated' characters. In a search for information on the evolution of this system, Dr Paxman has continued his studies of the genetical control of pigmentation among the allied wild species.

These plants are generally pigmented in both stems and flowers with derivatives of petunidin but several white-flowered forms are known and it is these that have been most useful in furthering the analysis. An outstanding fact is that such white-flowered wild forms breed as though they were *PP* in constitution. From the evidence of several F_1 families, and an F_2 of *S. simplicifolium* × a cultivated diploid, it now appears that the wild white phenotype is due to a recessive, *co*, which when homozygous, suppresses pigmentation in the corolla; this gene is not known among the cultivated forms but is not unlike extreme *ff* in its action. It is therefore particularly interesting to have evidence from the *simplicifolium* F_2 that *Co* is linked to the *B-I-F* linkage group of the cultivars.

On present evidence, four species, *Solanum simplicifolium*, *S. maglia*, *S. chacoense* and *S. tarijense* seem to have this system, that is *PP*, producing blue pigmentation, suppressed in the flower by *coco*. The first three of these species are pigmented by petunidin derivatives while the last, *S. tarijense*, breeds in the same way but is biochemically distinct in producing an unacylated malvidin pigment; its hybrids with acylated petunidin-producing forms contained *acylated* malvidin pigments, so non-acylation appears to be associated with a recessive gene. Since the F_1 between *S. tarijense* and a cultivated form, *pp acac*, all contained acylated pigments, it looks as though the gene in *S. tarijense* is independent of *ac*, which has multiple effects on acylation, methylation and glycosidation (*J.I. Report*, 1957).

The white-flowered form of *S. soukupii* is morphologically distinctive in that the plant is completely acyanic—the first tuberous *Solanum* known to us which is so. Breeding with a *pp* Phureja shows that it is of constitution *PP CoCo* and that its own lack of pigment is associated with a recessive gene at a different locus. It thus differs from its relatives in the genetical control of pigmentation; that this is connected with a different block in pigment synthesis is suggested by Dr Harborne's observation (*J.I. Report*, 1960) that it forms derivatives of the unusual flavonol, myricetin.

Finally, white-flowered *S. kurtzianum* shows a distinctive breeding behaviour in segregating plants with white and with streaked corollas among its hybrids with other wild species. The streaked phenotype is known among wild

strains of this species. The genetics is yet unknown but it is clear that *coco* is not responsible.

To summarize, Dr Paxman's results seem to make it clear that the wild species display a rather widespread *P-Co* system but that they also present several genetical and biochemical features unknown among the cultivated diploids. Contrariwise, there is no sign of the development of the *PRAc BIF* system characteristic of the cultivated potatoes, though the suggestion that *Co* belongs in the *B-I-F* linkage group is of obvious evolutionary interest.

Incompatibility and Cultivar Evolution

The cultivated diploids have an *S* allele system and are therefore self-incompatible. The autotetraploid Andigena Group potatoes are, as expected, self-compatible (though not necessarily seed-fertile); in them the action of the *S* gene is suppressed by competitive interaction. Two interesting questions arise: first, are the *S* alleles preserved unchanged in the autotetraploids? and, second, can they be used as evolutionary markers at the tetraploid level, as they have already been used at the diploid? Dr Dodds has now found that aswers to these questions are, in principle, possible.

The mating tetraploid (♀) × diploid (♂) produces an array of tetraploids, triploids and diploids. In Dr Dodds's sample, using several newly collected Andigena clones crossed by a suitable diploid tester stock as male, the three classes were in the frequencies 26, 24 and 8, respectively. The first arises from selection of unreduced male gametes and is of no further interest; the second represents the expected triploid hybrids; and the third class comprises the polyhaploids that Professor E. W. Hougas and his colleagues at Wisconsin have shown to be fairly commonly produced by tetraploid potatoes. That the diploid class were true polyhaploids was neatly proved by the fact that none had either of the *S* alleles known to be present in the male 'parent'. By testing the plants with suitable diploids as males and examining the stylar reaction, Dr Dodds was able to show that two *S* alleles known in the cultivated diploids were present and functional in the polyhaploids and therefore in their parental tetraploids. The conclusion therefore is that the *S* system does indeed persist and it can be used as an evolutionary marker; for the latter purpose it is extremely powerful by reason of the high level of discrimination permitted by numerous alleles—even though somewhat laborious in use.

Interrelationships of Wild Species

Mr Marks has completed his studies of interspecific relationships in the group of Central American wild species included in the series Conicibaccata, Demissa, Longipedicellata and Piurana. He has used fifteen species (diploid, tetraploid and hexaploid) and has examined very nearly all the $15 \times 14 = 210$ possible combinations. Naturally, a great range of behaviour has been revealed, far too extensive for detailed summary in this *Report*. Some of the leading conclusions, however, are worth setting out here and it is convenient to do so in an order determined by the nature of the reproductive isolation mechanisms at work, from failure of fertilization to hybrid viability.

First, then, failure of fertilization as a result of pollen tube inhibition occurred in 144 cases. The amount of pollen tube growth was affected by the particular species used (e.g. Conicibaccata pollen was conspicuously strongly inhibited) and by polyploidy. This inhibition was stronger in $2x \times 2x$ and $4x \times 4x$ than in $6x \times 6x$. Further, there were signs of reciprocal differences in that $4x \times 2x$ was more inhibited than $2x \times 4x$; by contrast, in $4x \times 6x$ combinations, no reciprocal differences were apparent. If a generalization is possible it would seem to be that the lower the ploidy of the pollen, the greater the probability of inhibition.

Second, post-fertilization failure resulting in inviable seeds occurred in eighteen cases. Here also there was a ploidy effect, breakdown being most conspicuous in crosses between parents of different chromosome number.

Third, viable hybrids were obtained in forty-seven combinations. Crossability expressed as the 'number of hybrid plants per pollination' ranged from 77·218 in *S. stoloniferum* × *S. tuquerrense* to 0·010 in *S. verrucosum* × *S. demissum*. Generally, crossability was highest in matings expected to produce eupolyploid ($2x$, $4x$, $6x$) progeny, lowest where aneupolyploid ($3x$, $5x$) progeny were expected.

Fourth, chromosome pairing was irregular in thirty-nine hybrids, regular (bivalent-forming) in only eight, of which one was diploid (*S. verrucosum* × *S. chomatophilum*) and seven tetraploid (*S. oxycarpum* × *S. colombianum* and the six combinations of three species of Longipedicellata). Those with irregular pairing formed combinations of univalents and multivalents; in the observation that multivalents were more frequent in interseries than in intraseries crosses, there is perhaps just a suggestion of the diploidization effect recently discovered in wheat polyploids (R. Riley, V. Chapman and G. Kimber, *Nature, Lond.*, **183**, 1244, 1959).

Fifth, nearly all the surviving hybrids were vigorous plants. Two exceptions, however, were interesting in showing a characteristic unbalance rather late in life. The hybrids in question were *S. verrucosum* × *S. chomatophilum* ($2x$) and × *S. tuquerrense* ($3x$), so the unbalance is connected with the interaction between *S. verrucosum* and Piurana genotypes. Both hybrids—which have been raised in some numbers—were vigorous until near to flowering. The former then wilted and died, whether on their own roots or grafted to tomatoes. The latter hybrid became chlorotic, distorted and brittle but survived to flower and set a few tubers; and a tuber-grown generation repeated the cycle.

Resistance to Common Scab

Dr McKee has continued his studies of scab reaction in potato cultivars. The work has two aspects, namely: the development of reliable techniques of assessment of resistance and the breeding of scab-resistant lines of Andigena potatoes.

A reliable method of assessing scab resistance is essential both for genetical studies and for the selection of resistant clones suitable for breeding. In an investigation of the reliability of estimates based on pot tests, the incidence

of scab was scored on tubers of twenty-five varieties grown in a field plot at the Nottingham University School of Agriculture, in a field plot at the Institute and in 4-in. pots in the glasshouse at the Institute. Inoculum, consisting of cultures of *Streptomyces scabies* dispersed in vermiculite, was added to one-half of the Institute plot. The performance of the varieties in the field was highly correlated with that in the pot test which can therefore now be used for an initial assessment of reaction to scab. The incidence of infection was much higher in the plots to which inoculum had been added than in the controls so it looks as though this technique will enable field plots to be prepared with a higher and more even infestation than occurs naturally.

Our thanks are due to Professor D. Ivins, Mrs N. MacDermott and their colleagues at the School of Agriculture, Nottingham University, for helpful co-operation in running the field trial at Sutton Bonington.

During the year Dr McKee completed his survey of scab reaction in some 500 C.P.C. Andigena stocks with the examination of a further 90 lines. None of the plants examined showed immunity but a few clones consistently proved to be highly resistant.

He now intends to investigate the inheritance of resistance in selected clones and to transfer this resistance to a Tuberosum background. Diallel crosses were made during the year between the seven most resistant and two susceptible clones but only two, one resistant and one susceptible, proved to be pollen fertile and, of the remainder, three failed to set berries. The number of plants in the crossing scheme will be increased, in the hope of obtaining a wider range of crosses, by including some with a lower degree of resistance.

A Natural Selection Experiment with Wild Species

The function and status of virus resistance genes in wild potato populations is something of a mystery. Surveys based on collections suggest that they are generally uncommon and therefore do not apear to have the selective advantage that might be expected of them. A knowledge of the selective effects involved would obviously be of considerable intrinsic interest; in principle, natural selection experiments with artificial populations might be expected to provide a model of what happens in the field, and such experiments have the added interest that very few studies of this kind on higher plants are on record.

Dr McKee has therefore set up a long-term experiment designed to estimate changes in gene frequency in four wild potato strains. The starting materials in each case are F_2 families segregating for a virus reaction gene; all populations are carried at two levels of infection (high—infectors interplanted; and low—natural infection only); and each is replicated five times on the basis of 100-plant sub-populations. The plots are scattered round the estate and, when the experiment is fully under way, $4 \times 2 \times 5 \times 100 = 4000$ plants will be grown each year. The plant materials chosen are: *Solanum stoloniferum* segregating immune vs. susceptible to virus *Y*; two lots of *S. demissum* segregating hypersensitive vs. susceptible and systemic hypersensitive vs. susceptible to virus *Y*; and *S. acaule* segregating immune vs. susceptible to virus *X*. The

two different types of reaction in *S. demissum* have been the subject of comment in a previous *J.I. Report* (1960).

The experiment, supplemented by suitable sampling, should provide estimates of means and errors of selective values of the various genotypes under different intensities of selection and of the parameters of the breeding systems of the three species. The indications are that all three are rigorous inbreeders but this has not been tested. It is unfortunate that the only self-incompatible outbreeder available that offers a usable virus resistance gene is *S. chacoense*; this would be excellent experimental material but is potentially a weed and so cannot be planted outdoors.

Following a preliminary experiment with *S. demissum* in 1960, which indicated that the main experiment would be technically manageable, Dr McKee made a proper start with three strains this year; stocks of *S. acaule* only became available during the year and will not be ready for inclusion until 1962. No estimates of gene frequencies among the progeny of the 1961 populations are yet available but field sampling indicated that the interplanting of infectors was indeed an effective means of raising the probability of infection of susceptible plants.

Resistance to Virus Y

A considerable number of the potato samples collected by Dr Dodds and Dr Paxman in South America (*J.I. Report*, 1960) were infected with potato virus *Y* and thus provided a broad collection of isolates of the virus. From the plant quarantine viewpoint, it is important to know something about the range of pathogenicity of the isolates and this Dr McKee has tested against a known virus resistance gene, that controlling *Y*-immunity in *S. stoloniferum*. The results are also of interest to the plant breeder because our *Y*-immune breeding lines have been selected for immunity only to certain common English strains of the virus and might conceivably be susceptible to some foreign strains. Accordingly, seedlings of C.P.C. 28.2, an immune line of *S. stoloniferum*, were inoculated mechanically with eighty-two of the isolates and the inoculated seedlings later examined for infection by back-testing to White Burley tobacco; no virus *Y* was recovered. Thus specialized strains of the virus capable of overcoming the immunity derived from *S. stoloniferum* are, at least, uncommon; this result, so far as it goes, is satisfactory from the quarantine viewpoint and also offers encouragement to the breeder that his immunity will be 'permanent'.

Breeding against Late Blight and Virus Y

The season was devoted to getting crosses of the twelve clones selected as most promising in 1960 and to continued assessment of the material on hand. The preliminary trials of twelve clones run at Cambridge in 1961, with the kind co-operation of Mr J. C. Cullen (*J.I. Report*, 1960), suggested that one was very promising and two others worth further trial. Four more were added to these on the basis of this year's performance so that altogether there

are seven clones of some promise. Stocks of these are being increased in the glasshouse and further trials are planned for next year. Meanwhile, preliminary wart-resistance tests are being done at the Plant Pathology Laboratory at Harpenden with the kind co-operation of the Director, Mr W. C. Moore. Seed of all the 1960 selections, backcrossed to various domestic types, is available and will be grown and screened early in 1962. Thus, these backcross stocks provide the material with which to carry the breeding a stage further if this proves necessary.

Variability and Utilization of the Andigena Group

The rationale of these experiments was outlined in the last *Report* (1960). In 1961 about 9000 plants were grown and these fell into two groups: (*a*) open pollinated populations undergoing mass selection, and (*b*) pedigree families. Of the former, the majority were raised at Bayfordbury, but about 2000 were grown at the Rosewarne Experimental Horticulture Station, with the kind approval of the Director, Mr F. W. Shepherd. Mr Simmonds made two journeys to Cornwall during the summer, one to study the plants during growth and the second to harvest and make selections.

A general breeding plan for the open pollinated populations has now been defined and is in operation. Briefly, the plan is to make selections on tuber characters in seedling populations, grow the tubers the following year and take seed samples from the resulting plants; in parallel, seedling populations raised from the tuber selections of two years before are also grown and selections from them go into the tuber population of the following year. The result is a recurrent cycle of tuber and seed propagation, seed being taken only from plants selected on the basis of tuber performance.

Standards of selection must necessarily change with the state of the populations. In the early stages, with very poorly adapted stocks, mere survival and moderate cropping is all that can be aimed at; later, once fair adaptation has been achieved, selection will be intensified towards the 'Tuberosum type' (which is hard to define but not difficult to recognize), with the ultimate aim of recreating the group. Some selection for disease resistance is also being carried on, less as a matter of design than as an automatic consequence of field cultivation: potatoes grown outdoors at Bayfordbury suffer severe natural leaf roll attack, those at Rosewarne (and at Bayfordbury in some seasons) are subject to epidemic blight. There is therefore considerable natural selection which is being supplemented by the deliberate destruction of visibly virus infected plants and by the selection of plants apparently more resistant to blight than their neighbours. The Rosewarne plot was started in order to get an effective blight selection differential, since it was expected that Bayfordbury would often prove too dry to be satisfactory for this purpose; in fact, 1961 was an exceptionally dry summer and we had little blight at Bayfordbury, so the Cornish plot, in which the disease was late but very severe, at once proved its worth.

It is to be noted that this breeding plan merely does systematically what the earlier potato breeders did with such success: namely, grow open pollinated

seeds from selected clones under field conditions which favour the selection of disease resistance.

The progress of selection will best be studied several years hence by comparison in the field of all the generations raised from remnant seed. Meanwhile, it may be of interest to record that very considerable progress was apparent in 1961. This was evident because the selected population (raised from 1960 seed of 1959 tuber selections) could be directly compared with an unselected mass of seedlings (drawn from the C.P.C. Andigena stocks) which were grown to provide more variability among the basic material of the experiment. The following Table summarizes the results:

TABLE 2

Population	Discarded[1]		Survived[1]	Tubered[2]	Selections[3]
	Weak	Leaf roll			
Unselected (5300)	20	30	51	49	15
Selected (2700)	22	33	45	77	43

Figures are percentages: [1] of initial populations, [2] of survivors, [3] of surviving plants which had tubered.

Evidently, one cycle of selection increased the frequency of daylength-adapted plants by 50 % and trebled the frequency of desirable types among those that did tuber. The difference, indeed, was obvious at a glance; however, no selection approached a good Tuberosum type in yield nor yet even the better Andigena pedigree selections described below. This is a promising start but there is a very long way to go.

The pedigree families (referred to as (*b*), above) showed an even more dramatic response, They were all raised from crosses of selections made among the 1959 growing of C.P.C. Andigena lines. Though a minority of plants did not tuber, and there were others which had undesirably long stolons, the general level was far above that of the open pollinated populations and the best plants (17 out of 600 were selected for further breeding) were well in the Tuberosum range of performance. This, so far as it goes, is encouraging but rapid response is a function of severe selection and only five parents contributed to these families. The genetic base is therefore narrow and it is yet far too early to guess what the long term prospects are.

Flavonol Glycosides of Solanum

Dr Harborne has continued his studies of the potato phenols and has made considerable progress in the identification of the flavonol glycosides of potato flowers. One correction to an earlier account (*J.I. Report*, 1959) is to be noted; the two glycosides, provisionally designated as kampferol and quercetin 3-rhamnosylglucoside, 7-glucosides, are in fact 3-glucosylrhamnosylglucosides. The trisaccharide present in these glycosides has not yet been completely characterized, but it is known to be different from that present in two related triglycosides which occur in tea leaves. The presence of 3-glucosylglucosides of kampferol and quercetin has been noticed for the first

time in potato flowers. They usually occur as minor components in association with the ubiquitous 3-rhamnosylglucosides, but are the major components of *S. ehrenbergii* and are best isolated from this source. The nature of the glucose-glucose linkage in these compounds is not known, but three out of the eight possibilities have been eliminated by comparing the disaccharide formed by hydrolysis with authentic glucose-containing disaccharides.

Dr Harborne, in collaboration with Dr Paxman, has also investigated the inheritance in two wild species of genes which control the production of one of the flavonol triglycosides mentioned above. Thus, glucosylation of quercetin 3-rhamnosylglucoside with the formation of the 3-glucosylrhamnosylglucoside, has been found in *S. stoloniferum* and *S. chacoense*, to be under monogenic control (locus designated *Gl*). The specificity of the system catalysing this step in synthesis is such that a small amount of quercetin 3-diglucoside is produced at the same time, presumably by transfer of glucose to the 3-glucoside, which is present only in the recessive form (*glgl*). This system, however, has no effect on the anthocyanins present; in fact, glucosylation of anthocyanidin 3-rhamnosylglucosides (at the 5-position) is known to be controlled by the *Ac* gene (*J.I. Report*, 1957).

The flavonol glycosides, which occur in relatively high concentrations in potato flowers, are not present to any appreciable extent in other parts of the plant. However, Dr Harborne has found two different flavonol glycosides to be characteristic of potato seeds. They are kampferol 3-di- and 3-triglucoside, 7-rhamnoside; in having sugars attached in both the 3- and 7-positions they are unusual since only four such pigments have previously been found in plants. Furthermore, the kampferol 3-triglucoside 7-rhamnoside is the first flavonoid tetraglycoside to be found in nature. Indeed, tetraglycosides in general are rare; the tuberous Solanums, however, provide not only the seed flavonol but also two other examples, since two steroidal alkaloids, demissine and tomatine, are of this nature.

Flavonol 3,7-glycosides

Following the discovery of flavonol 3,7-glycosides in potato seeds, Dr Harborne looked for similar substances in other plants and, in fact, found a total of six in four different species. Thus, 3,7-glycosides perhaps occur more frequently in nature than a study of the literature would suggest. One of these pigments is quercetin 3-diglucoside, 7-glucoside which is present in the purple flowers of *Petunia* cultivars. Two others occur, together with the known kampferol 3,7-dirhamnoside, in white flowers of *Lathyrus odoratus* and appear to be kampferol 3-glucoside, 7-rhamnoside and kampferol 3-xylosylgalactoside, 7-rhamnoside. A fourth glycoside occurs in white flowers of *Matthiola incana* and is probably kampferol 3-arabinosylrhamnoside, 7-rhamnoside. The location of the sugars in these 3,7-glycosides is difficult to determine because they are very easily hydrolysed; present evidence indicates the above structures for them, but these may require revision.

The fifth and sixth substances presented a different problem since they proved resistant to acid hydrolysis; they occur in the leaf of *Tulipa*. Earlier

investigations by Dr E. C. Bate-Smith and Dr T. Swain, of the Low Temperature Research Station at Cambridge, suggested that these pigments were derivatives of glycoflavonols, compounds in which the sugars are attached to the 6- or 8-position by a carbon–carbon linkage. However, both glycosides are rapidly hydrolysed by β-glucuronidase and this and other experiments indicate that the compounds are the 3-*O*-rhamnosylglucoside,7-*O*-glucuronides of kampferol and quercetin. Apparently, it is the combination of a rare sugar, glucuronic acid, and its position of attachment which is responsible for the low rate of acid hydrolysis.

A New Anthocyanidin and an Associated Flavonol

The common flavonoid aglycones are so widely distributed in higher plants that it is a rare event to find new structures among them. Dr Harborne, however, finds that one such compound is present in the flowers of *Plumbago capensis*. It turns out to be a new anthocyanidin, capensinidin, which is present as the 3-rhamnoside and is probably 5-*O*-methylmalvidin; accompanying it is azalein (5-*O*-methylquercetin 3-rhamnoside), which has previously only been found in *Rhododendron mucronatum*. A survey now shows that, besides occurring in forty-four out of eighty-three species of *Rhododendron*, azalein is also present in *Ceratostigma*. This last genus was examined in the course of a deliberate search through members of the Plumbaginaceae and nearly allied families. We are indebted to the Directors of the Cambridge Botanic Garden and of the Royal Botanic Gardens, Kew, and the Chief Ranger of Windsor Great Park for the provision of material for these surveys.

Acylated Flavonols

Whilst it has long been known that anthocyanins are often acylated by cinnamic acids, corresponding acylated flavonol glycosides have been described only recently. One such compound, *p*-coumaroylkampferol 3-glucoside, has been reported in *Tilia argentea* and *Rosa canina*. Dr Harborne has now found another such pigment in leaves of *Pisum sativum*: it is a *p*-coumaroylquercetin 3-diglucoside. Whilst the kampferol 3-glucoside of *Tilia* and *Rosa* is reported to have the acyl group attached to the 7-hydroxyl group, it seems more likely, *a priori*, that it is attached through the glucose in the 3-position. Such sugar-acyl linkages are considered characteristic of all those acylated anthocyanins which have been recently investigated (e.g. those of the potato). The structure of the *Pisum* glycoside is not yet known; its determination waits upon unambiguous methods, which Dr Harborne is trying to develop, for fixing the position of the acyl group in this and other acylated flavonoids.

5. DEPARTMENT OF CELL BIOLOGY: DR HARRIS'S REPORT

The main theme of research in the Department continues to be an examination of the structure and function of the ribonucleic acid in the nucleus. Several workers are engaged on different aspects of this problem, but other lines of work are also being pursued.

Synthesis and Breakdown of Nuclear RNA: The Relationship between Nuclear and Cytoplasmic RNA

Dr Harris and Dr Watts have continued their studies of the kinetics of synthesis and breakdown of RNA in HeLa cells. By the use of a new technique, involving fractionation of the cells with phenol-saturated water, the nuclear RNA labelled after a short exposure of the cells to a radioactive RNA precursor could be separated from the labelled cytoplasmic RNA. This separation permitted the simultaneous determination of the specific activities of all four bases in the two fractions both during the period of labelling and when labelled cells were transferred to non-radioactive medium. This resulted in a much more precise analysis of the interrelationship of the two types of RNA than has hitherto been possible. It was found that the RNA which became labelled rapidly in the nucleus was not necessarily a precursor of the cytoplasmic RNA but was, for the most part, rapidly broken down within the cell to compounds of small molecular weight (H. Harris and J. W. Watts, *Proc. roy. Soc.* **B**, in press). Dr Harris and Dr Watts had previously demonstrated the existence of a labile nuclear RNA in the macrophage; but this is a rather specialized non-multiplying cell, and there was therefore some doubt about the general applicability of the findings. The demonstration of a labile nuclear RNA in exponentially growing HeLa cells removes this doubt. In the light of the present findings in the HeLa cells the available autoradiographic evidence suggests that at least some of the nuclear RNA will prove to be metabolically labile in most, if not all, animal and plant cells.

Is the Labile Nuclear RNA Broken Down Within the Nucleus, or is it Transferred to the Cytoplasm before Breakdown?

Dr Harris and Dr H. W. Fisher (a visiting worker) have devised a new method for the isolation of intact nuclei from HeLa cells (H. W. Fisher and H. Harris, *Proc. roy Soc.* **B**, in press). All the nuclei in a population of cells can be recovered and the isolated nuclei are free from adherent cytoplasm. No detectable amount of DNA and not more than a few per cent. of the labile nuclear RNA are lost from the nuclei during isolation. The labile nuclear RNA can be isolated from the nuclei in a form

suitable for physical examination. Dr Fisher has been examining the sedimentation velocity and other physical characteristics of this RNA. The cytoplasmic fraction, after separation of the nuclei, lends itself readily to the preparation of cytoplasmic ribosomes having characteristic sedimentation velocities. The cytoplasmic preparations are being screened for the presence of a fraction having the physical and metabolic characters of a labile nuclear RNA. The methods now available should permit detection of such a fraction if it exists, and an examination of its metabolic relationship to the labile nuclear RNA should give some indication of whether the latter is transferred to the cytoplasm before being broken down.

Relationship of Nuclear RNA to DNA

Dr McLeish has worked out methods for isolating nuclei from fixed roots of various plants. The methods have so far been used most extensively on several species of *Allium* which show differences in ploidy. By a combination of optical and chemical techniques a systematic study is being made of the relationship between the amount of DNA in the cell and the amount of nuclear RNA.

Base Composition of Nuclear and Cytoplasmic RNA

The techniques already described permit the isolation of the various types of RNA from the nucleus and cytoplasm in quantities adequate for base analysis. Dr Spencer is examining the base compositions of these RNA fractions with special reference to any relationship they might have to the base composition of the DNA.

RNA and the Metaphase Chromosome

By the use of autoradiographic techniques Mr La Cour has examined whether RNA is present in the metaphase chromosome. Convincing evidence has been produced that the metaphase chromosomes do indeed contain RNA, and the metabolic behaviour of this RNA is now being studied.

Nucleotide Sequences in DNA

Mr Riley is examining methods for increasing the resolution of sequence analysis in groups of pyrimidine nucleotides released from DNA by the diphenylamine reaction. The possibility is being investigated of extending this type of statistical analysis to samples of DNA isolated from different cell types from the one organism.

Concentration of Amino Acids and Nucleotides in the Intracellular Pools of Multiplying and Non-multiplying Cells

There is some indication that the capacity of multiplying cells to concentrate precursors of protein and nucleic acid differs from that of non-multiplying cells. This problem is being investigated by Dr Stickland on the regenerating liver of the rat. In the adult rat the normal liver shows very

little mitotic activity, but, if the bulk of the liver is surgically removed, the cells of the residual portion, after a lag period of some 18 to 24 hr., begin to multiply rapidly. The organ is thus transformed from a population of predominantly non-multiplying cells to one of predominantly multiplying cells. Dr Stickland is examining the amino acid and nucleotide composition of the intracellular pool of the organ under normal conditions and in the various stages of regeneration.

Development of Techniques for the Clonal Growth of Plant Cells

Dr Sunderland has been endeavouring to evolve techniques which will permit clonal growth from single cells of *Haplopappus*, *Tradescantia* and other plants which have chromosomes particularly suitable for cytological work. Suspension cultures of various plant cells have been established, and colonies have been grown from very small inocula on agar plates. The possibility of using 'feeder' layers of X-irradiated cells to promote the growth of single cells is being investigated. If clonal growth of a suitable cell line can be achieved, an attempt will be made to study the mechanism of chromosomal replication through several cell generations.

Enucleation and Nuclear Transplantation Studies in Acetabularia

Earlier this year Miss Jahnz spent two months in Professor Hämmerling's laboratory at Wilhelmshaven in order to learn the techniques necessary for the culture and manipulation of *Acetabularia*. Cultures of *A. mediterranea* and *A. crenulata* have now been established in the Department and a full cycle from zygote to zygote has been carried through. Studies are now being initiated on the RNA metabolism and enzyme composition of enucleated cells and cells which have received nuclei from a different species.

Electron Microscopy

Mr Crawley has continued his studies on the fine structure of plant and animal cells. During the year two particularly encouraging advances were made.

Nuclei isolated from HeLa cells were greatly distended by immersion in hypotonic solutions, and were then examined at very high magnification. Regular fibrous structures were observed which had approximately the dimensions one would expect of DNA-protein fibres. A detailed statistical analysis of the size and distribution of these fibres is being made. This would appear to be the first time that fibres of these dimensions have been demonstrated in somatic interphase nuclei.

No electron microscopic studies on *Acetabularia* have yet been made, due apparently to the difficulty of obtaining suitable fixation procedures for this material. Mr Crawley has now devised a new technique of fixation which permits excellent electron micrographs to be made of *Acetabularia* at various stages. The fine structures of interspecific grafts and of transplanted nuclei are therefore now open to study.

6. DEPARTMENT OF PHYSIOLOGY AND PLANT CULTURE: MR LAWRENCE'S REPORT

The Mark II and III growth rooms and the cabinets previously described (*J.I. Report*, 1960) are now in routine use. This year two other rooms have been fitted out, one as a subsidiary growth room, with control of light intensity, daylength and (over a limited range) temperature and the other for the preparation of growth-room cultures. The provision of these various rooms and the cabinets completes the facilities necessary for the Department's programme of work.

Tomato

Early growth and development. Dr Hussey has continued his work on the development of the young tomato and has now obtained a more complete picture of the effects of temperature and light intensity on the development of the shoot apex. The effects of high and low temperature (25 and 15° C., respectively) have now been studied at three levels of radiation: 400, 800 and 1600 f.c. Considerable enlargement of the shoot apex always takes place during the vegetative phase before the first inflorescence is initiated. At 15° C. the apex begins to enlarge from the time of cotyledon emergence onwards and shows a gradually increasing relative rate of enlargement throughout the vegetative phase. At 25° C., on the other hand, there is initially a lag period when very little enlargement of the apex occurs, the duration of this lag period being longer the lower the light intensity. The lag period is followed by an increasing relative rate of enlargement which approaches the relative rate at 15° C. about the time of flower initiation.

The rate of leaf production is accelerated by both temperature and light intensity, but for any particular environment it remains constant or nearly constant with time. New leaf primordia are produced at regular intervals irrespective of changes in the rate of enlargement of the apex. The two processes of leaf primordia formation and apical enlargement thus appear to be independent. More leaves are produced before flowering at the higher temperature and the number of extra leaves thus produced is greater the lower the light intensity. The leaves formed during the lag period in apical enlargement roughly account for the number of extra leaves formed.

It has also been found that the length of the lag period and the number of extra leaves initiated at the higher temperature are both enhanced if the plants are grown in a larger pot. This effect is independent of the nutrient supply and appears to result from increased root growth during the early vegetative phase.

Light and temperature régime in glasshouses. The investigation of growth and development of the tomato in the variable and suboptimal light conditions prevailing in glasshouses during the winter months has been continued by Mr Calvert.

A further series of experiments has been carried out with the object of finding optimal night temperatures commensurate with the amounts of light-energy entering the glasshouse from day to day. Weekly growth rates based on the dry weight of tops of Potentate seedlings one to six weeks' old were measured during the period mid-October to mid-March. The experiments differed from those carried out the previous year (*J.I. Report*, 1960) only in that a higher range of night temperatures was employed, namely, 60, 64 and 68° F. with a day temperature of 64° F. throughout. The results were very similar to those obtained last year and can be summarized as follows:

(1) On only four occasions out of thirty-six did the plants grown at a night temperature of 60° F. show the greatest dry weight increase but the differences were not statistically significant.

(2) It was not possible to distinguish between the effects of night temperatures of 64 and 68° F. The largest dry-weight increment was recorded on sixteen occasions for both conditions.

(3) Though the plants were grown in a variety of light conditions ranging from 15,000 to 100,000 f.c.h. per week there was no clear indication that the plants' night temperature requirements changed with the light conditions.

This year's results have shown, as did last year's, that over a growth period of one week, the dry-weight increment was significantly reduced when the night temperature was 4° F. lower than the day temperature. This could, of course, merely be the result of lowering the mean (24 hr.) temperature. However, if this were the case one might also have expected a difference between weights of plants grown at the two higher temperature régimes. It appears that some exploration of the effects of the day/night temperature relationship would prove rewarding at this stage of the investigation.

Flower abortion. One of the more serious troubles from which tomatoes grown in winter and early spring may suffer is a condition designated as 'truss abortion' in which all or part of an inflorescence fails to develop. It is seen most frequently in the first truss since this is the one that is most likely to be initiated and to develop during periods of low light intensity. It is not known how early in life a period of adverse light conditions predisposes the plant to abnormal development of the first inflorescence.

An investigation has been started by Mr Calvert with the object of defining the period of sensitivity and also the critical levels of light intensity and temperature responsible for 'truss abortion'. A pilot experiment has been completed in which plants, at successive stages of development, were subjected to very adverse conditions (low light intensity and high temperature) for a period of ten days. During the periods before and after this treatment the plants were grown at a high light intensity and moderate temperature, conditions which were considered favourable for normal development. There were five transfers to the adverse conditions; the first took place shortly after initiation of the first inflorescence and the others followed at intervals of five days (60,000 f.c.h.). Sample dissections of the apex were made at the time of each transfer. Control plants remained in the favourable conditions throughout.

At a later stage the number of flowers on the first inflorescence was recorded

and the number of flower buds failing to open normally was taken as the criterion for abortion. Plants transferred on the first and second occasions were indistinguishable from control plants but plants transferred on the third, fourth and fifth occasions showed an increasing tendency to abortion of the first inflorescence. It is of interest that at the time of the first and second transfers the plants had initiated the first inflorescence only, but at the third transfer the second inflorescence was also developing.

It was clear that with the levels of light intensity and temperature employed in this experiment the plants were unaffected by periods of adverse conditions occurring up to ten days (120,000 f.c.h.) after initiation of the first inflorescence. Thereafter plants showed an increasing degree of inflorescence abortion.

It remains to be seen whether similar results can be obtained over a range of climatic conditions.

The rogue tomato. The rogue tomato plant has often been described in qualitative terms (e.g. it is 'bushy' in growth, the first inflorescence frequently aborts) but very rarely in quantitative terms. It is known that the frequency of rogues in rogue-producing varieties is increased by high temperatures during germination and the expression of the character after germination seems to be in some measure determined by light conditions (D. Lewis, *Heredity*, **7**, 337, 1953). As both temperature and light have marked influence on the growth and development of normal tomato plants, Mr Lawrence has begun experiments to identify more precisely the nature of the rogue character, to establish its range of expression as influenced by genotype and environment, and to inquire into the process of induction. A start has been made mainly using E.S. 5, a variety that readily produces rogues under the appropriate conditions. Care was taken to maintain the plant-to-plant environment as uniform as possible at all stages from sowing, so that comparison of rogue with normal plants would be reliable.

In an initial experiment, seeds of E.S. 5, Ailsa Craig, and Kondine Red were germinated at a controlled temperature of 30° C. transferred when the radicles were 3–4 mm. long to pots of *JIPI* and grown on, in April, in a glasshouse the temperature of which was maintained between 25 and 30° C. until the seedlings had their first pair of leaves. The number of rogues later counted in fifty plants of each variety were E.S. 5 twelve, Ailsa Craig one, and Kondine Red none. The mean number of flowers per plant borne on a sample of ten plants each of normals and rogues of E.S. 5 were: flowers $10{\cdot}1 \pm 0{\cdot}03$ and $7{\cdot}7 \pm 0{\cdot}07$, respectively, on the first inflorescence and $9{\cdot}7 \pm 0{\cdot}08$ and $10{\cdot}6 \pm 3{\cdot}03$ on the second inflorescence. All the inflorescences on the normal plants had a single branch as had also the first inflorescences on the rogues. But, referring to the second inflorescences of the rogues, two plants had three branches, five two branches and only three had single branches. Further, the rogues often had one more petal and stamen per flower than the normals. Since all the plants were raised under near identical conditions, the extra floral parts and the two- and three-branched second inflorescences in the rogues must be regarded as an expression of the rogue character, i.e. of 'bushiness'. The rogue plants were conspicuously ahead of their normal sibs

in development, e.g. in the twelve plants of E.S. 5 mentioned above, the first flower on the first inflorescence was open in 66 % of the rogues but only 8 % of the normals.

To characterize the rogue more precisely, detailed comparison was made between the aerial portions of normal and rogue sibs of E.S. 5 when the plants were about 35 cm. high. The results, in summary, were as follows: The rogue bears more leaves than the normal on the main shoot, but its leaves and petioles are some 20 % smaller. The number of laterals is the same on both normal and rogue but stem, leaf and petiole weights are about 70, 100 and 50 % greater, respectively, and leaf area about 100 % greater in the rogue. Taking the grand totals, stem and leaf weights are similar in both normal and rogue, but in the latter the mean weights of petioles and leaves and the mean leaf area are only some 50, 60 and 70 %, respectively, of those in the normal. Thus, in the rogue, increase in the number and weight of leaves on the main shoot and in the length and weight of lateral shoots is accompanied by a reduction in the size of all parts of the aerial structure of the plant. Since the total weight of normals and rogues is the same, this reduction is what would be expected if the efficiency and amount of carbon fixation were similar in the two types of plant.

One point of general interest has emerged from these initial inquiries. The statement (Crane, *The Fruit, the Seed and the Soil*, 3rd ed., 1954, p. 57 and Lewis, see p. 35) that the first pair of leaves in rogues are about equal in size, whereas the first leaf is much larger than the second in normals, is not an adequate distinction. Several varieties, including non-rogue producing ones, produce many normal plants having equal sized first leaves.

Experiments are in progress to determine the effects of (1) the level, duration and alternation of high and low temperature, (2) the stage of treatment including the parent plants and (3) the light integral after germination.

Potato

The growth and development of six *Solanum* species, *chacoense*, *demissum*, *moscopanum*, *soukupii*, *vernei* and *verrucosum*, are being studied in the glasshouse by Mr Alvey. Seeds of each species were sown on successive dates between 20 February and 30 October, the daylength of any sowing date differing by $1\frac{1}{2}$ hr. from the daylength of the previous one. Periodic samplings were made and the fresh weights of haulms, stolons, tubers and berries were recorded. The apices were dissected to study flower initiation and dates of anthesis were also scored. The light integral and temperature were measured. All sampling is not yet completed, but the following preliminary observations have been made.

Stolons were initiated by all species throughout the period of the experiment. *S. chacoense* bore tubers at all times, but the other species did not initiate tubers until the daylength was less than about 12 hr. *S. moscopanum* initiated very few tubers.

Flowers were initiated by all species if the daylength was between 9 and

16½ hr., and it may be that some species will initiate flowers in even shorter daylengths. Flowers initiated in daylengths shorter than those shown below did not reach anthesis.

S. chacoense	9 hr.	*S. soukupii*	9 hr.
S. demissum	11 hr.	*S. vernei*	13 hr.
S. moscopanum	9 hr.	*S. verrucosum*	11 hr.

All species, including *S. chacoense*, flowered and bore berries after sib crossing, during long days. Species which did not tuber in long days kept growing throughout the summer and eventually bore tubers in daylengths shorter than 12 hr. All species died after they had produced tubers.

Subsequent analysis may prove that in *Solanum*, as in other species of plants, aspects of development which are apparently affected by daylength are, in reality, affected by other environmental factors associated with daylength, e.g. temperature, light integral (amount of light) and light intensity. Environmental effects not elucidated by further analysis of these glasshouse experiments will be studied in more strictly controlled environments.

7. DESCRIPTION OF MERTON FRUITS

MERTON PRINCESS

Origin Strawberry Seedling J.I. 547 raised in 1950 from a cross between Royal Sovereign and an unnamed variety No. 31 from U.S.A.

Fruit

Size Large throughout season.
Shape Rounded conical; some early fruits irregular or wedge-shaped.
Colour Light glossy red; pale and uneven when the plants are too leafy.
Flesh Rather soft.
Season Mid- to late.

Plant

Habit Very vigorous and leafy especially on heavy soils. Distinct down-cupped leaflets. Carries a heavy crop.
Disease Resistant to mildew and *Verticillium wilt.* Susceptible to red core and Botrytis under unfavourable conditions.

Remarks Tends to be too leafy in an over rich soil.

MERTON CHARM

Origin Apple Seedling No. 2326 raised in 1933 from the cross McIntosh Red × Cox's Orange Pippin.

Fruit

Skin Pale greenish yellow ground with an orange red flush covering from one-third to two-thirds of the fruit, no russet, smooth, slightly greasy.
Shape Round, slightly flattened, even; stalk of medium length and thickness in an even cavity.
Size Uniform medium size ($2\frac{1}{4} \times 2\frac{3}{4}$ in.).
Eye Small, closed in a shallow even basin.
Flesh Tender, crisp, of excellent texture, creamy yellow, very juicy.
Flavour Sweet, very refreshing.
Season September to October.

Tree

Flowering Mid-season, fertility good, diploid.
Habit Moderately spreading, moderate vigour; crop good and regular.

Remarks Award of Merit, R.H.S., 27 September 1960. An excellent garden apple with possible merit as a commercial variety.

MERTON CRANE

Origin Cherry Seedling No. 519 raised in 1925 from the cross Bigarreau Napoleon × Bigarreau de Schrecken.

Fruit

Skin Deep purple, almost black.
Size and shape Large, round, with stalk of medium length.
Flesh Deep crimson, firm and juicy.
Stone Medium to large.
Season Mid-July, with Roundel.

Tree

Flowering Late, should be compatible with all groups except II and IX.
Habit Makes large tree. Branches inclinded to be upright; very stiff, close spurring—rather like Napoleon.
Disease Small amount of gumming.

MERTON LATE

Origin Cherry Seedling No. 659 raised in 1926 from the cross Belle Agathe × Bigarreau Napoleon.

Fruit

Skin Orange yellow, overspread with deep crimson.
Size and shape Medium, round, long and slender stalk.
Flesh Orange yellow, very firm and juicy.
Stone Medium size.
Season Early September.

Tree

Flowering Incompatibility group IX.
Habit Large tree; spreading. Large amount of lateral wood.
Disease Gums badly. Some bacterial canker.

Remarks One of the latest cherries to ripen.

MERTON MARVEL

Origin Cherry Seedling No. 868 raised in 1930 from the cross Noble × White Bigarreau.

Fruit

Skin Deep purplish crimson.
Size and shape Large, blunt heart-shaped, medium to long slender stalk.
Flesh Crimson, firm and juicy.
Stone Medium size.
Season Mid-July.

Tree

Flowering Incompatibility group not yet known.
Habit Compact tree. Size medium to large. Tends to form too much thin lateral wood.
Disease No signs of gumming or bacterial canker. Very healthy.

8. PERSONNEL RECORD

		Date
	Appointed	
Dept. of Genetics	Dr A. Coddington	1. xii. 61
Dept. of Potato Genetics	Mr E. Hall	14. viii. 61
Dept. of Cell Biology	Dr T. Spencer	1. vi. 61
	Dr W. T. Riley	1. x. 61
	Mr M. G. Jones	18. ix. 61
	Miss B. Slade	15. v. 61
	Mr R. Tate	4. ix. 61
Administration	Mrs J. R. Prew	5. vi. 61
	Resigned	
Dept. of Applied Genetics	Mr Watkin Williams	31. vii. 61
	Mr N. E. G. Gilbert	30. vi. 61
	Mr G. D. Rowley	30. ix. 61
Dept. of Genetics	Miss J. E. Long	30. xi. 61
Dept. of Potato Genetics	Dr K. K. Pandey	31 xii. 61
	Miss J. Corner	28. ii. 61
	Miss J. M. Dymond	31. xii. 61
	Miss A. T. Kobylanska	31. xii. 61
Dept. of Cell Biology	Mr J. I. McCubbine	30. ix. 61
Dept. of Physiology and Plant Culture	Dr R. M. Whittle	30. ix. 61

Mr Watkin Williams: awarded the degree of D.Sc. (University of Wales)

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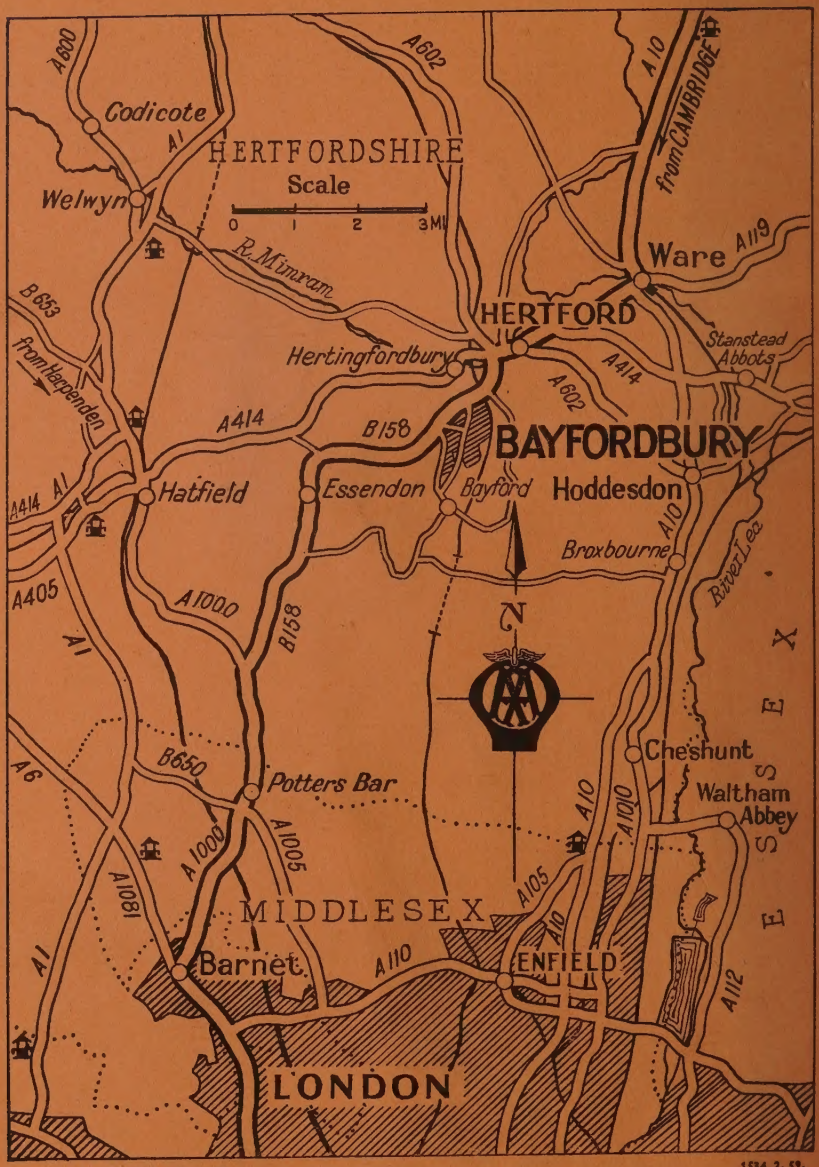

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